

# An optical example for classical Zeno effect

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In this brief report, we present a proposal to observe the classical zeno effect via the frequent measurement in optics.

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Zeno paradox, such as the problem of the so-called flying arrow, contrary to the evidence of our senses, seems never happen in real classical world. But this paradox is believed to be possible realized uniquely in quantum world, known as quantum Zeno effect proposed by Misra and Sudarshan [1] in 1977, because of probability properties of quantum states and the projective measurement in quantum mechanics (for a review, see Ref. [2]). Recently, one of us (Gu) argued that the classical Zeno effect is possible recovered with Super Mario's intelligent feedback [3]. Later, we further showed that the decay of a classical state in classical noise channels can be significantly suppressed with the aid of the successive repeaters [4], in this sense we claim that the classical Zeno effect may exist in classical stochastic process. In this report, we present a proposal to observe the classical zeno effect in optics. The evolution of the polarized-light intensity in the designed system are strongly affected by the measured times.

As shown in Fig. 1(a), when a linear polarized light beam with initial intensity  $I_0$  is incident on a series of successive Faraday media, the polarization direction of the beam gradually changes with the increasing number of the Faraday media. Assuming that the initial direction of light polarization is in the  $y$  direction and the angle for the polarization rotation from the input to output changes  $\pi/2$ , then the intensity of the linear polarization

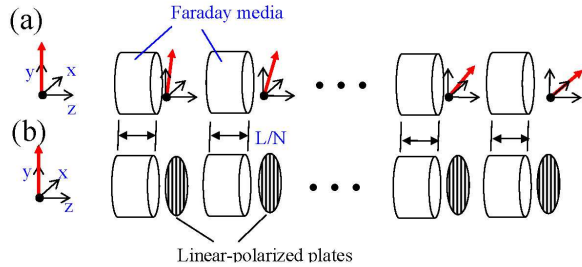


FIG. 1: (Color online) (a) Setup for successive polarization rotation with a series of Faraday media and (b) setup for the observation of optical Zeno effect with vertical-polarization measurements after each Faraday medium. Each Faraday medium with the length  $L/N$  induces a polarization rotation angle of  $\pi/2N$  and  $L$  is the total length of all Faraday media.

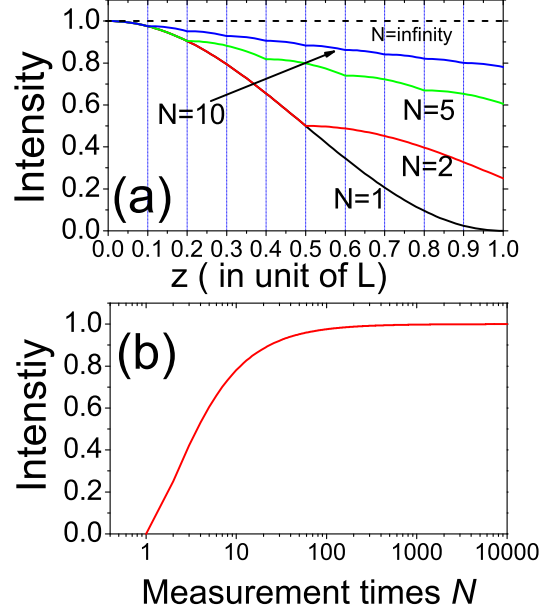


FIG. 2: (Color online) (a) Intensity evolutions of the polarized beam in the  $y$  component as a function of distance  $z$  for different measurement times. (b) Dependence of the output intensities of the polarized beam on the measurement times  $N$ .

beam for the  $y$  component is given by

$$I(z) = I_0 \cos^2 \left[ \frac{\pi z}{2L} \right], \quad (1)$$

where  $L$  is the total length of all Faraday media that induce the  $\pi/2$  rotation of light polarization, and  $z$  is the internal distance inside the Faraday media. Since there is no measurement in (a), the intensity of polarization beam for the  $y$  component evolves smoothly as a function of  $z$ .

However, once the measurements are presented in Fig. 1(b), the evolution of the resulted intensity is dramatically changed. In Fig. 1(b), we do a vertical-polarization measurement (along the  $y$  direction) after each Faraday medium, then the resulted intensity of the polarization beam for the  $y$  component becomes

$$I(z) = I_0 \left[ \cos^2\left(\frac{\pi}{2N}\right) \right]^{i-1} \cos^2 \left\{ \frac{\pi}{2L} \left[ z - \frac{L}{N} (i-1) \right] \right\}, \quad (2)$$

where  $N$  is the total number of Faraday media with the same polarization rotation angle  $\pi/(2N)$ , and  $i$  denotes the  $i$ th Faraday medium at which the distance  $z$  is located. Therefore, the intensity for the polarization light beam for the  $y$  component at the output end finally becomes

$$I_{\text{out}} = I_0 \left[ \cos^2 \left( \frac{\pi}{2N} \right) \right]^N. \quad (3)$$

When the measured times increase to be infinite, i. e.,  $N \rightarrow \infty$ , the output intensity at the output end will be close to  $I_0$ . This indicates that the initial intensity of the linear polarized light beam for the  $y$  component, passing through numerical Faraday media with small polarization rotation angles, will not decay after the infinite measurements. Figure 2(a) shows clearly the changes of the intensities of the linear polarized light in the  $y$  component

for different measurement times, and with the increasing of the measurement times the decay of the intensity becomes slower. In Fig. 2(b), it is found that the output intensity at the output end becomes larger and larger, and it gradually tends to be one with the increasing of the measurement times  $N$ .

In summary, instead of the memory effect in the previous scheme [4], in the present scenario we use the polarization property of light to recover the Zeno effect. We can see that the measurement of the light polarization plays the same role of the projective measurement in quantum mechanics. However, all the quantities involved here are classical. In a word, Zeno effect does happen in the classical world.

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